



Relative sea level trends from tide stations: How are they determined and what do they tell us?

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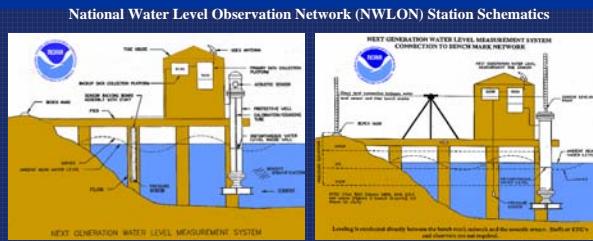


The Center for Operational Products and Services (CO-OPS) operates the National Water Level Observation Network (NWLON) which currently consists of 187 stations. Many stations have decades of accumulated sea level data permitting the accurate calculation of linear trends.

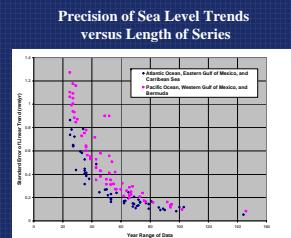


Since the tide gauges record the level of the ocean *relative* to land, any local or regional vertical land motion is included in the calculated rates as well as the long-term global sea level rise. Vertical land motion can be caused by tectonic activity, glacial isostatic rebound, river sediment loading, or underground fluid injection or removal. Using tide gauge measurements for estimating long-term sea level change requires proper gauge operation and maintenance, routine monitoring of a local tidal bench mark network for vertical stability, and continual quality control of the data.

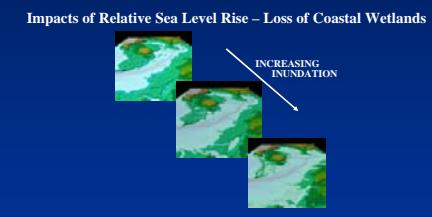
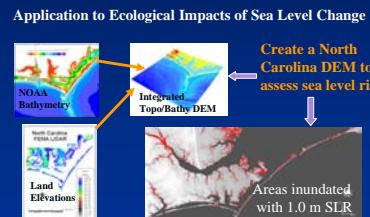
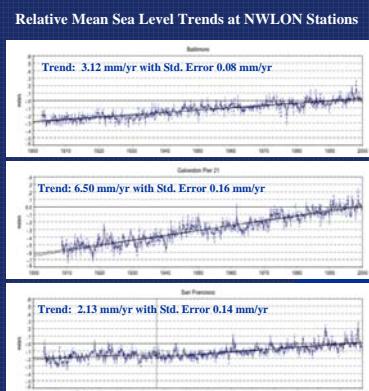
A typical station configuration has a primary acoustic sensor with its protective well, backup pressure sensor, data collection platform, GOES antenna, and local bench mark network. The sensor is connected to the local tidal bench marks through repeated annual leveling, thus preserving the continuity of the data record relative to a known, documented, consistent reference datum.



The precision or uncertainty in the calculated trend depends mainly on the length of the sea level time series. Trends derived from the longest time series have the smallest error bars, whereas trends derived from even 25 to 35 years of data can have wide error bars due to the oceanic variability. Interannual and decadal variability is greater at the Pacific Ocean and western Gulf of Mexico stations. Therefore, more years of data are required at these stations than at the Atlantic Ocean or eastern Gulf of Mexico stations to determine sea level trends to a specified precision.



Sea Levels Online, a section of the CO-OPS website, at <http://tidesandcurrents.noaa.gov/slrends/slrend.shtml>, was created to present the relative sea level trends, seasonal cycles, and interannual and decadal variations at 117 long-term CO-OPS stations based on data up to the end of 1999. These plots show the monthly mean sea levels after the annual seasonal cycle has been removed, along with the trend and its standard error. The seasonal cycles and the interannual variations, shown on separate plots, are caused by fluctuations in coastal ocean temperatures, salinities, winds, atmospheric pressures, and currents. The interannual variations for many U.S. west coast stations are closely related to the El Niño/Southern Oscillation. Next year, sea level trends will be recalculated based on data up to the end of 2005 and the Sea Levels Online webpages will be revised.



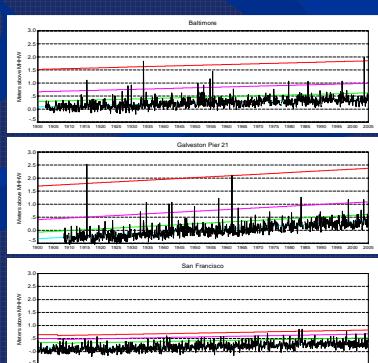
NOAA-USGS Topographic/Bathymetric Project – Tampa Bay, FL

CO-OPS' long-term sea level records support a number of NOAA projects and applications. For the North Carolina Sea Level Rise Project, a bathymetric/topographic digital elevation model (DEM) was created using LIDAR land elevations and NOAA bathymetry referenced to a common datum to create baseline inundation maps for varying amounts of future sea level rise. This project built on the success of the Tampa Bay project which, in cooperation with the USGS, produced maps showing the effects of differing levels of inundation.

Relative Mean Sea Level Trends at Global Reference Stations



Highest Monthly Water Levels with Annual Exceedance Probability Levels
1% (red), 10% (pink), 50% (green), and 99% (blue)



Another useful application of long-term tide gauge data is a return frequency analysis of the monthly and annual highest and lowest observed water levels. On the east coast and Gulf of Mexico, hurricanes and winter storms interact with the wide, shallow, continental shelf to produce large extreme storm tides. On the west coast, the height of extreme events, such as those caused by El Niño-related storms, are limited by the narrowness of the continental shelf. A generalized extreme value (GEV) distribution can be derived for each station after correcting the values for the long-term sea level trend. Theoretical exceedance probability curves give the 99%, 50%, 10%, and 1% annual exceedance probability levels shown on the plots. These levels correspond to average storm tide return periods of 1, 2, 10, and 100 years. The results from this analysis will be available in the future on the CO-OPS website.